PATTERN DEVELOPMENT IN MAMMALS AND BIRDS

II

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PARTIAL ALBINISM IN WILD MAMMALS

Partially albinistic individuals of species that normally are wholly pigmented, occur frequently in a wild state, and almost any large series of a given species may contain a few. I have examined many such, in which it was perfectly evident that the white mark was due to areal restriction of some one or more of the primary pigment areas just as described in the various domestic species. It is apparent that the white markings in both are quite comparable, but in species under domestication no agency seems present whereby such pied individuals are eliminated, whereas in a wild state the sudden acquisition of a large amount of white in an individual would not only render him too different from his fellows, but might put him at a disadvantage because of a conspicuousness to which as a species he had not yet become accustomed.

There are many other species in which, as we now see them, white markings form a permanent and normal part of the pattern. Among those in which these white markings are few or simple, it is often evident that they are merely primary breaks between the pigment patches that have become more or less fixed by long periods of selection, whether natural, sexual or otherwise. As I shall endeavor to show, there are species in which a beginning has already been made towards the development of a pied pattern, though it has not yet become well fixed. Still other species show a more complicated white and pigmented pattern, the white portions of which can not readily be derived from primary breaks alone. Such I take to be highly developed patterns and make no attempt

to analyze them here. Examples of this type are seen in the zebra, the spotted skunks (*Spilogale*), the striped weasel (*Ictonyx*). Probably more than one factor is responsible for some of the combinations of stripes and spots seen, for example, in certain spermophiles (*Citellus 13-lineatus*), but I shall not now attempt a discussion of these.

One of the most frequent manifestations of pigment reduction in mammals is the presence of a white spot in the normally pigmented forehead. This is due primarily to the reduction of the ear patches, which fail to meet at their median edges. Perhaps, too, the apparent loss of the crown patch in some mammals still further tends to lessen the amount of pigment production at this point. Rabbits and hares very often have more or less white in the forehead, but none of the species has developed this sufficiently to make it a permanent mark. Moseley in his "Naturalist on the *Challenger*," speaks of a "black variety" of wild rabbit—doubtless introduced—"with a white spot on the forehead" as occasionally found on Teneriffe, Canary Islands, but this mark is common, and I have seen it in such widely sundered species as the eastern varying hare of New Hampshire and the black-necked hare native to Java. A specimen of Leisler's bat (*Nyctalus leisleri*) in the Museum of Comparative Zoology has a white spot in the middle of the forehead and another on the mid-ventral line of the abdomen—the first a primary break between the ear centers, the second probably a ventral primary break between those of the sides. Among the Insectivora, the West Indian *Solenodon paradoxus* has a white patch at the nape of the neck which has become a permanent part of its pattern. It is clearly the enlargement of a primary break separating the ear patches and neck patches on the median dorsal line. It is a fact of much interest that in a considerable series of this species in the collection of the Museum of Comparative Zoology hardly two have it developed alike, but it varies from a few white hairs to

a large patch 15 × 10 mm. wide. Evidently it has not yet become precisely defined in its limits, though now a permanent mark of the species.

White marks in the forehead are common among the species of the Mustelidæ or weasel family. A narrow white median line is present in the Javan mydaus and in the skunks (*Mephitis*) as part of the permanent pattern.

In the badger (*Taxidea*) a white line is not only present on the forehead, but it is often extended medially so as to separate the pigment patches of both sides of the body. In the New York weasel (*Mustela noveboracensis*) of the eastern United States a few white hairs are often present on the forehead, and other instances could be multiplied. Among monkeys, a white spot on the nose is present in some species of *Lasiopyga,* and in an allied genus *Rhinostigma,* it is elongated vertically to form a white streak.

A yet more illuminating case is that of the Muskeget Beach mouse (*Microtus breweri*) a derivative of the common brown meadow mouse of the New England mainland. On this island of white sand off the Massachusetts coast, a pale variety has developed which is very distinct from that of the neighboring shores. Not only is it a paler race, but albinism also has begun to appear, so that occasional individuals have a white fleck between the ears, showing the drawing apart of the ear patches. Of a series of 62 specimens in the collections of the Museum of Comparative Zoology and the Boston Society of Natural History, no less than 13 had such white flecks, and one had in addition a white spot just in advance of the shoulders, marking the line of separation between neck and shoulder patches. In our studies on the heredity of coat colors in mice, Professor Castle and I discovered (Allen, 1904; see also Little, 1914) that the pied condition is recessive in the Mendelian sense towards the self colored, so that partial albinos bred to wholly pigmented mice produce in the second generation, if interbred, 25 per cent. of spotted young. The figures

given above (13 in 62) are near this in case of the Muskeget mouse, but the matings are of course more promiscuous. The case is interesting in connection with the studies of Ramaley (1912) and Pearl (1914), tending to show that in a mixed population the recessives may increase so as to exceed the dominants. Although the spotted mice do not, in case of this species, exceed the unspotted individuals, they nevertheless are of far more frequent occurrence than they are in the mainland representatives of the species. This accords with the fact that island-living mammals are very commonly albinistic, and the cause is doubtless that the population is much more inbred, so that the recessive condition of partial albinism is more likely to be propagated than if successive generations have a wider range over which to spread. It seems probable that heredity will tend to increase the proportion of spotted mice of Muskeget, and that if this condition is disadvantageous, a large part of the spotted individuals will be killed off, yet in the course of time they may become adjusted to this condition and will survive in increasing proportion till the white mark becomes characteristic of all the animals. Cory (1912) records the capture of seven muskrats at Hayfield, Iowa, all of which were uniformly marked, having a white ring around the neck and the entire underparts, feet, and end of tail white. I can think of three causes influencing the status of such white markings. These markings may be inherited in a purely automatic way as unit characters; but if thus inherited they may be (1) increased through selection, natural or sexual; or (2) eliminated by the same agent; or (3) they may be, at first, of no influence at all in the economy of the animal and persist or not, according as they are heritable.

I have mentioned that island mammals tend to be more albinistic than their mainland representatives. Other cases may be mentioned, as the common squirrel (*Sciurus vulgaris leucurus*) of Great Britain, which differs notably from that of the continent in having frequently a

white or whitish tip to the tail, often for one half its length. A similar white tip is occasionally seen in our red squirrel (*S. hudsonius*) as an albinistic mark, and is due, of course, to the terminal restriction of the rump patches. The deer of Whitby Island, Puget Sound, are said to be much marked with white, and sundry marsupials of Papua as well as the monotreme *Zaglossus* are subject to white markings. In the cuscus (*Pseudochirus*) the pigment is sometimes restricted to small patches and round spots scattered on the back, those in the region of the shoulder of a different color from those of the side and rump patches. Another instance is that of the white-footed mouse of Monomoy Island, Massachusetts, the mid-ventral parts of which are pure white to the roots of the hairs, an albinistic condition to be clearly distinguished from that in which the belly appears white, but only because of the white *tips* to the hairs whose bases are dark-pigmented.

The restriction of the rump patches so as to produce a white tail-tip is common among mammals. It is found in occasional specimens of many species as the shrew mole (*Blarina*), Brewer's mole (*Parascalops*), the meadow jumping mouse (*Zapus*), the white-footed mouse (*Peromyscus*), and squirrels (*Sciurus*). In some it has become developed as a permanent and characteristic mark, as in the woodland jumping mouse (*Napæozapus*), the red fox (*Vulpes*), such genera as *Hydromys, Tylomys,* the Virginia opossum (*Didelphys virginiana*), the tree kangaroos (*Dendrolagus*). In many others a pure white belly is developed through ventral restriction of the shoulder and side patches.

Among ungulates the break between the ear patches has been developed to form a broad white blaze from forehead to nose in case of the blesbok (*Damaliscus albifrons*) of South Africa and in related species in East Africa. The chevron-mark on the forehead of certain antelopes is possibly a specialized development of the same thing.

White buttock patches are present in several unrelated ungulates—as the pronghorn (*Antilocapra*), the wapiti (*Cervus canadensis*), and the Rocky Mountain sheep (*Ovis canadensis*). Probably these are the result of restriction or total inactivity of the pigment patches covering the rump.

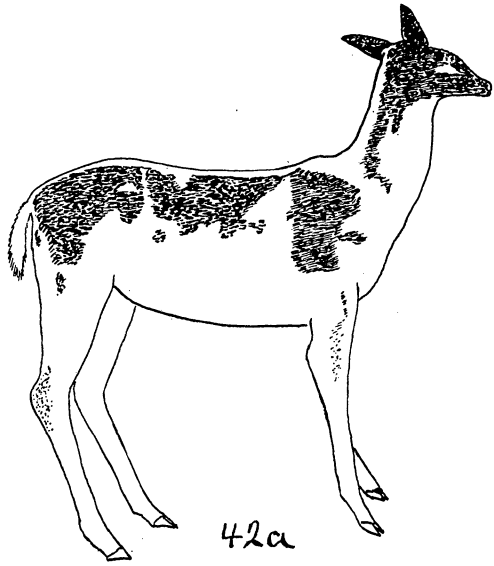


FIG. 42*a*. DIAGRAM SHOWING THE PIGMENTED PATCHES OF A PARTIALLY ALBINO DEER.

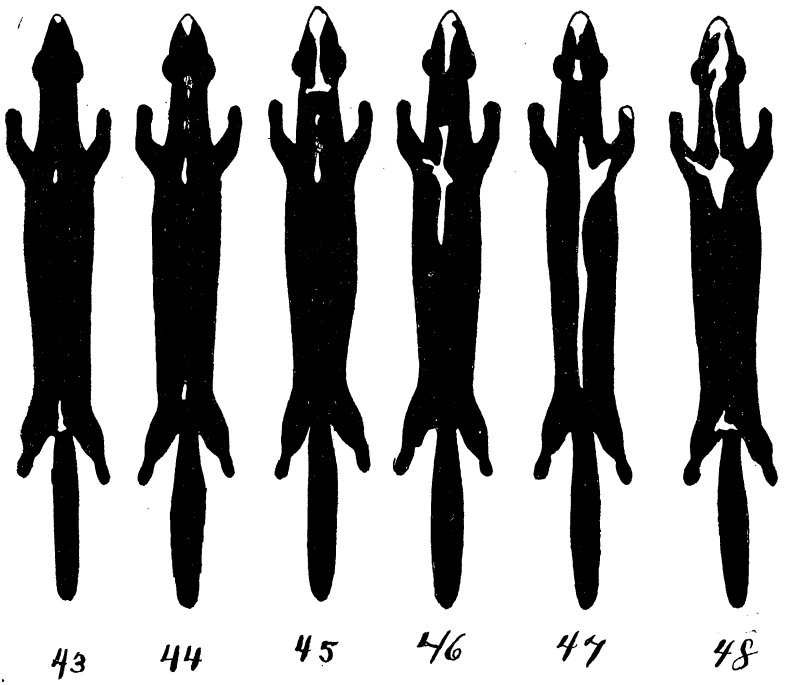
Among the deer family white is generally confined to the under surfaces and the primary white breaks have not been developed to form patterns. Albinistic deer are fairly common, however, and in Fig. 42*a* I have made a tracing from a photograph showing the side of a partially albino doe in which areal restriction of pigment has taken place in such wise that the primary patches are all indicated, and separated from those of the opposite half of the body by a median dorsal white line. The ear and the neck patches are joined, but a few small islands of pigment are left here and there, much as in cows.

In the young of many deer and in the adult of such species as the axis deer, a spotted pattern is developed.

There is an obvious tendency for the spots to become arranged in longitudinal rows, and intermediate stages may be found in which they coalesce to form broken lines. There is little doubt that the complete white stripes occurring in part of this pattern were formed originally through the coalescence of rows of white spots. In the tapir a somewhat similar spotted pattern is found in the young, while the adult Malayan tapir has lost the shoulder and side patches, producing thus a white-bodied animal, pigmented to the back of the foreleg and on the buttocks and hind legs. Among the ground squirrels (*Citellus*) a beautiful series can be picked out showing the transition from a uniform grizzled mixture of ticked hairs to indistinct spotting, then rows of white spots, and finally broken and complete longitudinal stripes. The production of these stripes I believe to be due, not to the development of breaks between the primary pigment patches, but to the action of a factor which is the negative of the so-called "English" marking in rabbits, so that instead of the *development of scattered small pigments spots* there are formed, instead, spots without pigment. That it is possible to evolve a striped pattern from spots through selection, I have no doubt, and indeed, it is generally believed. On the other hand, it is quite possible that the converse may happen, and spots result through the breaking up of stripes. According to the experiments of Professor Castle and Dr. MacCurdy, however, it seems to be a difficult matter to fix a given marking by rigid selection, yet it must be admitted that a few years' work even of careful breeding is nothing in comparison with the age-long selection that may have been at work on the species. That it is a difficult matter to produce a given pattern is further evidenced by the fact that in many species in which white markings regularly occur as part of the pattern, these are subject to great individual variation in their extent, showing that they are even yet not wholly definite.

It was formerly urged against evolutionary doctrine

that we do not now see its processes in action, that species are stable and subject to very little variation. This view, however, was found to rest on faulty observation, for, though some species are fairly stable, others are very plastic and exhibit before our eyes various steps in development. So in case of the development of a particular pied pattern, it is possible to see in certain species the actual course of its formation. Among mammals, the Mustelidæ or weasel family show several instances in



FIGS. 43–48. DIAGRAMS SHOWING RESTRICTION OF PIGMENTATION ON THE VENTRAL SURFACE OF MINKS (*Mustela vison*).

point. The common mink (*Mustela vison*) of northeastern North America is now in process of developing a pure white under side, such as is present in the New York weasel (*M. noveboracensis*) or the smaller Bonaparte's weasel (*M. cicognani*). The diagrams shown in Figs. 43–48 are from the fine series of mink in the collection of the Museum of Comparative Zoology and depicit the

under side of the specimens. In the large coastal race of mink found from southern Maine to the Carolinas (*M. v. lutreocephalus*), the entire pelage is usually brown, except for the chin which is white. Occasional white marks are present in some specimens along the mid-ventral line of the throat and chest, and between the hind legs. In the smaller typical *M. vison* of northern New England northward the white marking is apt to be more extensive, and in no two individuals exactly alike. The diagrams show the ventral markings of a few specimens from New England and Nova Scotia. In Fig. 43 the amount of white is very small. The chin spot, which represents the beginning of a break between the two ear patches at their antero-ventral extremity, is always present and has become now a fixed mark of the species, though variable in extent. A slight break in the center of the chest shows where the two shoulder patches have failed to meet, and a white spot at the anal region indicates a like restriction of the rump patches. Similar spots appear mid-ventrally in Fig. 44, with the addition of a few white hairs, medially at the upper throat, where the ear and neck patches join, and a few more on the lower throat at the line of union of the neck patches of opposite sides. In Figs. 45 and 46 no break is present on the abdomen, but in the former figure, a large transverse break has appeared on the upper throat where the ear patches fail to unite with the neck patches and with each other, and a median line runs forward to join the white of the chin, showing the greater restriction of the ear patches ventrally. An imperfect separation of these patches along the center of the throat has taken place in Fig. 47, and a more considerable break occurs in the same place in Fig. 46. In the Pacific Coast mink (*Mustela vison energumenos*) a well-developed white patch on the chest is rather characteristic, somewhat larger than in Fig. 45. This is due to the ventral restriction of the shoulder patches which fail to meet below. In Fig. 46 this white area is seen with a tongue extending upon the center of the lower throat, and on to

one fore leg, as well as in the mid line of the thorax, marking nearly the anteroposterior limits of the shoulder patch. The neck patches are not separated in this figure but have become so in Fig. 48, so that a continuous line of white runs from chin to chest. In Fig. 47 the shoulder and the side patches have both failed to join ventrally, and thus a broad white line is formed down the center of the belly from the conjoined neck patches to the rump patches. If all these breaks were to be present in a single animal, there would be a narrowed white area along the entire ventral side of the body from chin to anus, extending on to the lower side of the fore legs. Practically this condition exists in another species of the same genus, Streator's weasel (*Mustela streatori*) of the Pacific Coast, in which the throat, chest and belly are white but the width and boundaries of the white area are very variable in different individuals. It is therefore in a stage beyond that which the minks have reached, yet it has not attained the stage in which the white area is of definite and rather constant bounds, as in certain other weasels, for example *Mustela noveboracensis,* in which the white, of the belly extends nearly or quite to the lateral border of the body, but in different individuals varies slightly, and *M. cicognanii,* in which the white area of the belly constantly extends to the lateral boundary of the venter from throat to anus. This is the condition toward which the mink is tending.

Another interesting case in which a pattern mark appears to be evolving through the fixation of a primary break between pigment patches is that of the so-called tayra of South America (*Tayra barbara*) a large Mustelid. The Central American race (*biologiæ*) of this animal is wholly black, but the typical subspecies of Brazil and northern South America is subject to a varying amount of reduction in pigmentation. Curiously, this takes place at the posterior end of the neck patches or at the anterior part of the shoulder patches. Three of five specimens in the Museum of Comparative Zoology are marked in this

way. All have a triangular patch of white at the base of the throat ventrally, as a break between neck and shoulder patches and a partial separation of the neck patches from each other. Each has a *dorsal* mark of white; in the first a narrow linear break between the shoulders; in the second a broader transverse mark, and in the third a square patch of white occupying nearly the width of body between the shoulders to the base of the neck. The white throat marking increases in extent from first to third, just as does the dorsal marking. Probably in time this white mark, now of irregular size and appearance individually, will become a permanent part of the pattern. In this animal the entire head and neck are a grizzled gray as far back as the posterior limit of the neck patches, and the rest of the body is black. This, then, shows that the pigment patches of head and neck are differentiated in color as well, from the patches of the rest of the body. The occurrence of white markings in the back is relatively uncommon in mammals, though white on the under surfaces is common, and, as shown by Mr. Abbott H. Thayer, may be of real service to the animal as a factor in concealment.

In the development of white pattern-marks, the evidence seems to show that these come in at first as small and fluctuating spots, which may be of little effect in the economy of the animal. Their further development might lead to the extinction of the species if they render it too conspicuous to enemies, unless the species at the same time makes use of them or accommodates itself to their revealing effect. Often, no doubt, they may not be a source of danger at all. A case in point may be that of *Sciurus finlaysoni,* a Malayan squirrel, most of the individuals of which are largely marked with white, and of which specimens may be found side by side, varying from an almost entirely pigmented condition to one of completely white coat and black eyes. White squirrels are occasional in other species, as albinos, but these rarely survive more than a generation in the cases I have known, whereas

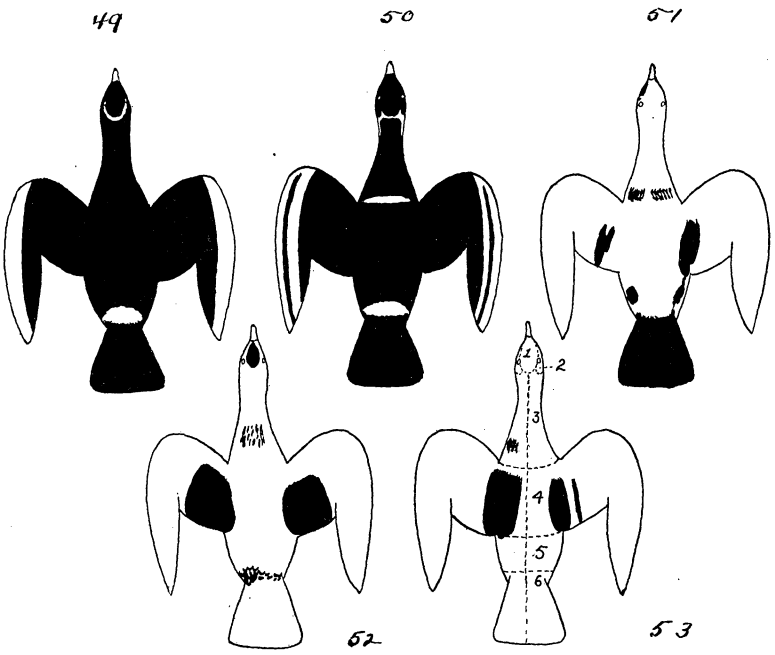
Finlayson's squirrel seems to have accustomed itself by gradual stages to the white condition, so that it is probably not at a great disadvantage by reason of its whiteness.

PIGMENT PATCHES IN BIRDS

In birds the same primary pigment patches seem to be present as in mammals, and they are homologous in the two groups. In defining the extent of the pigment patches, however, allowance must be made for the fact that the long feathers may cover a part of the body remote from their origin. The distribution of the feathers or the pterylosis of the species in hand must also be remembered. In order to arrive at the true interpretation of the patches, it is necessary to consider the pigment as projected back from the vanes of the feathers to the part of the body at their bases. By so doing, it becomes evident that a feather variegated with pigmented and unpigmented (or white) areas indicates none the less that the feather arises from a place of pigment formation. It is only a wholly white feather or patch of feathers that can be considered albinistic in the sense here intended. The factor determining the intermittent formation of pigment in the individual feather is probably a wholly different one from that determining the presence or absence of pigment formation at certain places on the body, though not necessarily different except in its intermittent action.

In the domestic pigeon of our streets and buildings, we have a species that in its wild state is normally fully pigmented except for a white rump patch. Under semi-domestication it has developed partial albinism to a large degree, so that it is possible to obtain a complete series representing on the one extreme a totally pigmented bird without a trace even of the white rump patch, and on the other extreme a bird of pure white plumage. A few of the intermediate stages in areal reduction of pigmentation are shown in Figs. 49 to 53, selected from birds raised for the market and, so far as known, not

bred for pattern. The first steps in reduction are shown in Fig. 49. Here there is seen first a crescentic band of white feathers passing from eye to eye around the occiput. This is a primary break marking off the crown patch posteriorly. This patch in birds, in contrast to its development in mammals, is the main patch of the head,



FIGS. 49–53. DIAGRAMS SHOWING PIGMENTATION IN THE DOMESTIC PIGEON.

covering the area from the base of the bill to the eyes and occiput. In Fig. 50 its posterior limit is similarly defined by a primary break separating it from the neck patches, and although it does not extend forward quite to the eye in this specimen, it shows a beginning of separation from the more lateral ear patches by virtue of the indentations on each side posteriorly. In Fig. 52, the crown patch is shown slightly reduced in extent and wholly separate from the ear patches, which have become inactive altogether. In Fig. 53 it has dropped out with the latter. It is evident then that by greater or lesser

reduction of the crown patch alone it is possible to produce a pigeon with a mere white spot at the back of the head, one with a white stripe from the base of the beak through the eyes to the back of the head (or some part of such a stripe) to a pigeon in which by the total reduction of the patch, the entire top of the head is white. Such specimens can be found in most any miscellaneous flock. There is a tendency often for the patch to be irregularly broken, sometimes divided almost into two parts, a result of the pterylosis to some extent.

The ear patches in pigeons, and probably in all birds, are rather insignificant, and the smallest of all the primary pigment areas. They include the feathers from the posterior angle of the lower mandible to the angle of mouth and thence back, including the ear coverts. I do not feel sure that the patches of opposite sides may not join on the chin, but the present evidence tends to show that the chin is pigmented by a forward extension of the neck patch, which, under reduction, often leaves a small island of pigment between the mandibular rami. In Fig. 50 the neck patches are seen to have broken away anteriorly from the crown and ear patches and the separation of the latter from the crown is indicated by deep reentrants along the line of the separation. In Fig. 51 a remnant of the ear patch of the left side alone remains in dorsal view, consisting of a small tuft of pigmented feathers at the fore end of the aural area and a single pigmented feather just behind it. In this specimen there are a few pigmented feathers on the chin as well, which I take to be an isolated bit of the neck patches.

The neck patches are bilateral in origin, and pigment the entire throat and neck back to a point corresponding to the base of the neck vertebræ. They meet the crown patch and separate the ear patches at the occiput. In the domestic pigeon the neck patches correspond very closely to the area of differentiated feathers that give the metallic reflections. In the reduction of this area it is common for the anterior part of the throat to be white, and then a

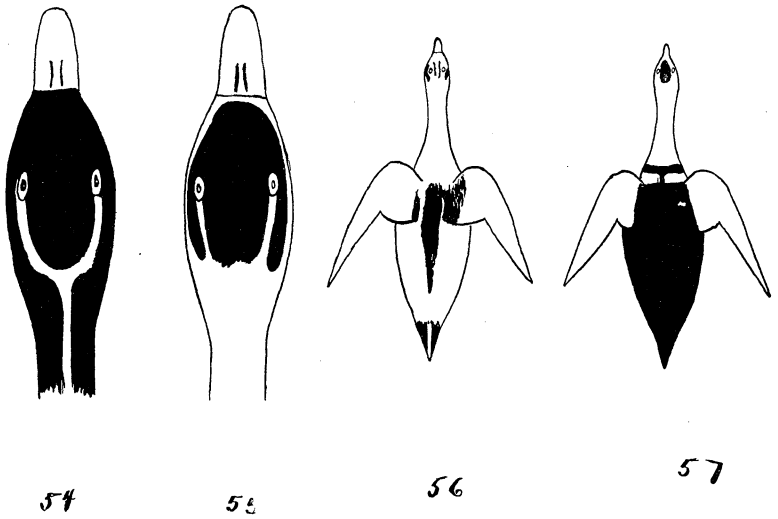
break occurs between the neck patches and those of the head as in Fig. 50. Posteriorly the neck patch under reduction may become separated by a white ring at the base of the neck, from the shoulder patches as in Fig. 50. The ultimate centers of these patches seem to be in the pigeon well back on the base of the neck. These are shown, of small extent, in Fig. 51, as two small areas of pigmented feathers, one on each side of the base of the neck. In Fig. 53, further reduction has taken place, so that the patch of the left side only remains as a small center. In Fig. 52 there is a large median dorsal patch, which, as in mammals, may represent the two centers of opposite sides which even under much reduction have not in this individual become divided medially.

A very common manifestation of pigment reduction in pigeons is to have the primaries or some of them white, as in Figs. 49 or 50. This indicates a failure of pigment to develop at the extremities of the shoulder patches, just as in mammals white forefeet mark a slight reduction of the same areas. It is a fact of much interest that in the guinea fowl (*Numida*), which has been under domestication but a short time comparatively, a distinct breed has arisen in which this same reduction of pigment is present, resulting in a speckled bird with pure white primaries and often a pure white area on the breast. In the pigeon, further reduction cuts off a narrow ring of pigment encircling the breast, or, it may be, broken in the mid-ventral line. This ring represents the reduced shoulder patches, and is to be seen in many wild species as a permanent part of the pattern. The white collar at the base of the neck in Fig. 50 marks the separation between the neck and the shoulder patches at the anterior border of the latter. In other specimens the patches are separated medially by a white area down the back. The ultimate centers of these patches seem to be near the elbow or on the upper arm at the base of the tertiaries, as seen in Figs. 52 and 53.

The side patches are rather small and seem to center, as in Fig. 51, near the groin on either side. They pigment the belly back of the breast area included by the shoulder patches, and extend on to the hind legs as well. In a specimen before me, the shoulder patches pigment the bases of the wings and the entire breast corresponding roughly to the length of the sternum, and tend to be separated by encroaching white feathers midventrally. The side patches are much more reduced, and are confined to a small area at the top of each thigh. The remainder of the patches has become inactive, so that a completely white belly and back result. A very common occurrence is the white rump patch due to the restriction of the side patches, so that a break occurs between them and the tail patches. The rump patches in birds are situated far back, as in mammals, and pigment the tail coverts and the rectrices as in Figs. 49–51. The bilaterality of the two patches is often indicated in pigeons by the occurrence of a few pure white rectrices in the center of the tail. Other birds show pure white feathers at either side of the tail, with a tendency to bilateral symmetry, a most important fact, since it indicates restriction at the outer extremes of these centers. In the restriction of pigment formation, the rectrices are the first to become white, as one would expect, since they are situated at the extremity of the body and farthest from the center of the patch. In Fig. 52 these centers are seen to be at the base of the tail above, and include the upper tail coverts. They are still joined medially, but that of the left side is more extensive than the patch on the right side. The approximate boundaries of the several pigment patches are indicated in Fig. 53 by dotted lines; 1 is the crown patch, 2 the ear patch, 3 the neck patch, 4 the shoulder patch, 5 the side, and 6 the rump patch, as they appear in a dorsal view. Ventrally the neck patch runs forward to the symphysis of the mandibles.

In a flock of domesticated mallard ducks which I studied, the same patches were found indicated, and

some of the details of these are shown in Figs. 54–56. In the male wild mallard there is no white in the pattern of the head and neck except a white ring at the base of the neck. In one of the domesticated breed, shown in Fig. 54, the crown patch was very beautifully marked off, as in the pigeon (Fig. 49), by a white band from eye to eye passing about the occiput. This duck was further interesting in showing the median division of the two neck patches, as a narrow white line running down the



FIGS. 54–57. DIAGRAMS SHOWING PIGMENTATION IN DOMESTICATED MALLARD DUCKS AND IN THE (WILD) LABRADOR DUCK (57).

back of the neck medially, from the occipital stripe. Another duck shown in Fig. 55 had lost the neck patches entirely, but showed the same occipital stripe bounding the crown patch posteriorly, and the ear patches dorsally. The ear patches still adjoin the crown patch anteriorly. In Fig. 56 is represented another of these ducks in which both ear patches are distinct and separate on either side of the head. The crown patch appears as two narrow lines of pigmented feathers which are not quite in contact posteriorly. I have not obtained a satisfactory explanation for the apparent tendency of this patch to

divide medially. Probably for some reason the formation of the pigment is more intense at the sides of the crown than in the center where the nerve and blood supply is less. In the pterylosis of this area the development of feathers is seen to be greater at the sides also.

The neck patches and the side patches are absent entirely, but the shoulder patches are both present, in Fig. 56, that of the right side covering the scapulars and middle of the upper back, that of the left side including a few only of the scapulars.

The tail patches are both present, and separate from each other, as shown by the median white rectrices.

In this same flock of mallards was a female which had a white ring at the base of the neck in the same situation as the white ring which in the male is a part of the permanent pattern. It was not quite complete dorsally, however, in this female, and was somewhat broader than regularly in the male. Nevertheless, it is apparent that this white collar in the male is merely a primary break between neck and shoulder patches that has become developed as a part of the normal pattern.

Stone (1912, p. 318) in his paper on the phylogenetic value of color characters in birds, hints at the existence of these patches. He says, in part:

> In matters of pattern there seems to be a deeper problem involved, *i. e.*, the determination of the cause governing the appearance of a differently colored patch on corresponding parts of the plumage of birds belonging to wholly different groups . . . or the presence of a mystacial stripe, a superciliary stripe, a light rump patch. . . . In fact if a bird exhibits a bright or contrasting patch of color, it is, in the vast majority of cases, found on one of several definite portions of the plumage, as the crown, the throat, the bend of the wing, the rump, etc.

These contrasting areas are due to the development of one or more of the primary patches, or of breaks between them, or again paler areas, as at the bend of the wing or on the rump, indicate often a lessening of pigment intensity at a distance from the respective primary centers.

(To be concluded.)